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CENTRAL INTELLIGENCE AGENCY

INFORMATION FROM FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT

CD NO.

50X1-HUM

COUNTRY	USSR
SUBJECT	Economic - Coal
HOW PUBLISHED	Monthly periodical
WHERE PUBLISHED	Moscow
DATE PUBLISHED	Jan 1949
LANGUAGE	Russian

DATE OF INFORMATION 1949

DATE DIST. 26 May 1950

NO. OF PAGES 9

SUPPLEMENT TO REPORT NO.

THIS IS UNEVALUATED INFORMATION

SOURCE Ugol', No 1, 1949.

USE OF HEAVY SINGLE-BUCKET EXCAVATORS IN OPEN-PIT COAL MINES OF EASTERN USSR

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[Tables are appended.]

Open-pit coal mining consists mainly of removing the overburden from the coal seams and depositing it on the dumping grounds. There are two main systems for the removal of overburden: the transport (transportniy) system, which removes overburden by railroad to inside and outside dumping grounds, and the nontransport (bestransportniy) system, which deposits overburden by heavy excavators directly to the worked-out areas.

The nontransport system is economically more efficient than the transport method inasmuch as it does not require railroad transportation (such as locomotives, electric locomotives, dump cars, track-moving machines, traction substations, electrical contact network, etc.), building of roadbeds (including railroad tracks, ties, switches, and rock-loading stations), and repair and equipment installations (locomotive and railroad car depots and shops for servicing locomotives with coal, sand, and water). The number of workers is also greatly reduced.

Extensive development of the nontransport system, mainly developed by I. I. Kognovitskiy and N. V. Mel'nikov, has been assured by its simplicity and its highly technical and economic indexes. For the past 3 years, this method has been adopted in the pits of the Urals, Karaganda, and Raychikha. The following examples show the effectiveness and possible expansion of use of heavy excavators.

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1. Bogoslovskiy Lignite Deposit

This deposit consists of a single seam 25 meters thick which has a dip of 8-12 degrees. The seam is covered with rock up to 10 meters thick (clay, siltstone, argillite, and thin layers of sandstone). At present, overburden is being removed to a depth of 70 meters. The lower 12 meters are transferred by stripping excavators and walking drag lines which deposit the overburden in worked-out areas, while the remaining 40 meters are carried by railroad to dumping grounds outside the mining area.

Before 1944, the overburden from the lower bench was also carried to outside dumps by railroad. From 1944 to 1947, 5.7 million cubic meters of earth were deposited in an interior dump by the nontransport system of working the lower layers.

It is impossible to give a complete analysis of the effectiveness of the nontransport system in the Bogoslovskoye pits because both methods remained in use: railroad hauling was not discarded and the nontransport system was only used in a small, but very important, part of the operations, the working of the lower stripping benches.

The following average figures pertaining to the operations in the Bogoslovskiy pits show the economic advantages of the nontransport system.

a. The removal of 1.6 million cubic meters of overburden by the nontransport system, in 1947 would have required eight locomotives, 65 dump cars, construction of 12 kilometers of railroad line on the rock benches of the pit and dumping ground, and 230 workers for the service and maintenance of the railroad line and rolling stock.

b. Removal of overburden from the lower level to dumps outside the pits would necessitate the construction of a railroad line to the bottom of the pits. This would require building a grade out of the pit for the railroad and would therefore call for an additional excavation of 100,000 cubic meters. Furthermore, this grade would have to be shifted periodically as the working face was shifted, thus increasing the demand for labor and impairing operations of the railroad. Railroad performance would fall off 8-10 percent each time the grade is shifted.

c. Cost per one cubic meter of overburden is 3.3 rubles less by the nontransport than the transport system. From 1944 to 1947, 18 million rubles were saved by using the former method.

It is necessary to note, however, that in spite of the considerable advantages, the nontransport system of mining of the lower stripping bench has also several drawbacks.

Relatively small excavators with only limited operating range work the lower stripping benches. They are only able to work a bench which is less than 15 meters high and to dump the removed rock at a distance of not more than 10-15 meters. The walking drag lines, which are engaged in secondary dumping, also have an inadequate operating range. Their buckets are small and their productivity does not match the production rate of the entire deposit. The small operating orbit of the excavators (especially in secondary dumping) causes the dumps to slide down onto the coal seam and complicates working in the lower levels. Excavators (for primary excavation) with a bucket capacity of 10-15 cubic meters and walking drag lines (for secondary dumping) with a bucket capacity of 10 cubic meters and improve this situation.

The maximum height of a bench being worked is 35 meters (with use of blasting). The operating range of the walking drag line permits the safe piling of the overburden and the formation of piles with safe slopes. After 35 meters of bench are broken up, the excavator piles it in worked-out sections alongside the coal seam. A walking drag line which rests on the dumps removes the overburden to worked-out areas.

Technical and economic indexes of the transport and nontransport system in mining the lower stripping bench in the Bogoslovskiy deposit are shown in Table 1.

It is evident that the nontransport system, using heavy excavators, is many times more efficient than the transport system in mining the lower bench because:

a. The number of workers employed is decreased approximately 85 percent.

b. Productivity per worker is increased nearly 600 percent.

c. The weight of equipment and supplies per 1,000 cubic meters of daily stripping is decreased 80.5 percent.

d. The cost of equipment per 1,000 cubic meters of daily stripping is decreased 56 percent.

Heavy excavators will be used to an increasing extent in the Bogoslovskiy lignite deposit.

2. Mikhaylovka Lignite Deposit (Karaganda Basin)

This deposit consists of a horizontal layer up to 17 meters thick which is covered by a 30-meter-thick overburden of clayey shale, argillite, and sandstone. The nontransport system of removing the overburden is practiced here by pit No 1-2 of the Karagandauglerazrez Trust, using excavators of the 6 cubic-meter type. They are equipped with a dragline with a bucket capacity of 4.5 cubic meters.

The section of the deposit which is being worked by these excavators has an overburden of 15 meters and many old rock formations. The excavator stands on top of the overburden and deposits the removed rock in the worked-out areas.

From 1944 to 1947, 2,306,000 cubic meters of overburden were removed in pit No 1-2 by the nontransport system. In comparison with the transport system of mining, a saving of 3 locomotives, 30 dump cars, a track-moving machine, a banking plow (otvalnyy plug), 800 tons of rails, 20,000 ties, and 200 workers was achieved. As a result, production costs per cubic meter of excavation were considerably less than the expenditure in operating the transport system, and the technical and economic indexes were higher.

However, the relatively small operating range of the 6-cubic-meter type excavator and the thickness of the coal seam and overburden make it impossible to mine the entire Mikhaylovka deposit by the nontransport system (even in pit No 1-2, which does not have a thick coal seam or overburden layer, 30-40 percent of the excavated rock must be shoveled a second time). For example, in order to work pit No 4, which has a coal seam 17 meters thick and a layer of overburden 30 meters thick, the nontransport system requires a second excavator for reshoveling. A heavier excavator is needed to attain an efficient production level of the pit (productivity of the 6-cubic-meter type excavator is 1,500,000 cubic meters of overburden per year).

It would be possible to work the Mikhaylovka deposit completely and efficiently by the nontransport system by using heavy excavators (excavators with a bucket capacity of 15 cubic meters and walking drag lines with a bucket capacity of 10 cubic-meters). The excavator would perform the preliminary breaking up of the 30-meter stripping bench and the walking drag line would then remove the overburden to the worked-out areas.

Technical and economic indexes of the transport and nontransport systems in the Mikhaylovka deposit are shown in Table 2.

It is evident that the nontransport system is several times more efficient than the transport method because:

a. The number of workers employed is greatly decreased.

b. Labor productivity is increased

c. The weight of equipment per 1,000 tons of daily extraction is decreased 77.5 percent.

d. The cost of equipment per 1,000 tons of daily extraction is decreased 59.4 percent.

3. Raychikhinsk Lignite Deposit

This deposit consists of a single horizontal lignite seam, 5 meters thick, which lies under 5-60 meters of clay and sand. At present, a few sections, which lie under 10 meters of overburden, are being worked by the nontransport system. Excavators with a bucket capacity of 2.7-3.8 cubic meters are being used.

The technical and economical indexes attained by these excavators from 1945 to 1947 give the following information:

a. Overburden removed amounted to 2,510,000 cubic meters, of which 1.3 million meters were removed in 1947.

b. The removal of 1,300,000 cubic meters of overburden in 1947 by the nontransport system would have required, by the transport system, 3 locomotives, 30 dump cars, a track-moving machine, 900 tons of railroad track, 22,000 ties, and 350 workers.

c. Cost per one cubic meter of overburden in 1947 by the nontransport method was 2.8 rubles cheaper than the expenditures by the transport system.

The excavators used in this work had a small operating range and could only work the overburden to a depth of 8-10 meters. This was inadequate, since most of the pits were covered with 15 and more meters of overburden.

The Raychikhinsk deposit can be most efficiently exploited by the nontransport system by using heavy excavators with a bucket capacity of 15 cubic meters and walking drag lines with a bucket capacity of 10 cubic meters.

The technical and economic indexes of the Sorokinsk pits, which used heavy excavators, were computed to show the comparison between the nontransport and the transport systems (at a coefficient of overburden removal of 3.5 and at a volume of overburden removal of 4 million cubic meters per year).

Nearly 60 percent of the whole deposit lies under an overburden not more than 35 meters thick. This attests an excellent opportunity for using the nontransport system. The sections with thicker overburden layers will probably be worked by both methods, the nontransport system in the lower levels and transport in the upper (as in the Bogoslovskiy deposit).

As can be seen from Table 3, the nontransport system showed the following advantages:

a. The number of workers employed decreased 73 percent.

b. Productivity per worker is increased 350 percent.

c. The weight of equipment and material (metal) per 1,000 tons of daily extraction is decreased 44.5 percent.

d. The cost of principal mining transportation equipment and material (metal) per 1,000 tons of daily extraction is decreased 21.4 percent.

4. Cheremkhovo Coal Deposit

This deposit consists of a 7-meter-thick coal seam of composite structure. The overburden consists mainly of hard sandstones 20 to 70 meters thick. The coal reserves suitable for open-pit mining are very considerable.

The Cheremkhovo deposit will be worked by the nontransport system using heavy excavators with a bucket capacity of 15 cubic meters and drag lines with a bucket capacity of 10 cubic meters.

The walking drag line will shovel 70 percent of the total overburden. Production norms will be arranged to permit efficient utilization of both machines.

Table 4 shows the technical and economic indexes of the nontransport method. For reasons of comparison, the transport system for removing the overburden to piles inside and outside the pit (Khramtsovskiy Pit No 1) is also shown.

As can be seen from Table 4, the nontransport system showed the following advantages:

a. The number of workers is decreased 85 percent.

b. Productivity per worker is increased 530 percent.

c. The weight of equipment and metal per 1,000 tons of daily extraction is decreased 81.5 percent.

d. The cost of equipment per 1,000 tons of daily extraction is decreased 70.0 percent.

Table 1

Indexes	Nontransport System	Transport System (figures based on operations in upper levels)
Annual volume of overburden removal (1,000 cu m)	4,000	4,000
Height of stripping bench (meters)	35	35
Equipment		
Excavator with a bucket capacity of 15 cu m	1	--
Excavators with a bucket capacity of 3 cu m	--	5
Dragline with a bucket capacity of 10 cu m	1	--
29T drills	2	2
Series E locomotives	--	13
40-ton dump cars	--	160
45-ton railroad cranes	--	2
Banking plows	--	1
Railroad track (km)	--	21
Number of workers employed	67	450
Productivity per worker (cu m)	204	30.2
Weight of equipment and materials (metal per 1,000 cu m of daily stripping (tons)	149	765
Cost of equipment and materials (metal) per 1,000 cu m of daily stripping (1,000 rubles)	1,080	2,580

Table 2

Indexes	Nontransport System	Transport System
Annual volume of overburden removal (1,000 cu m)	4,000	4,000
Overburden removal (cu m/ton)	1.6	1.6
Maximum height of stripping bench (meters)	30	30
Annual coal production (1,000 tons)	2,300	2,300
Main equipment for stripping		
Excavator with a bucket capacity of 15 cu m)	1	--
Excavators with a bucket capacity of 3.8 cu m	--	4

(Continued)

Indexes	Nontransport System	Transport System
Drag lines with a bucket capacity of 10 cu m	1	--
Locomotives	--	26
Dump cars	--	154
Main coal-mining equipment		
Excavators with a bucket capacity of 2 cu m	4	--
Excavators with a bucket capacity of 1.5-2 cu m	--	9
Dump trucks with a 25-ton capacity	11	--
Locomotives	--	13
Number of workers employed	360	1,980
Productivity per worker (tons)	21.6	3.8
Weight of equipment and materials per 1,000 tons of daily extraction (tons)	345	1,530
Electric power consumption (kw-h/ton)	2.32	--
Cost of equipment per 1,000 tons of daily extraction (1,000 rubles)	2,570	6,320

Table 3

Indexes	Nontransport System with Heavy Excavators	Transport System
Annual volume of overburden removal (1,000 cu m)	4,000	4,000
Overburden removal (cu m/ton)	3.5-5.3	3.5-5.8
Maximum height of stripping bench (meters)	35	35
Annual coal mining (1,000 tons)	1,200-700	1,200-700
Main equipment for stripping		
Excavators with a bucket capacity of 15 cu m	1	--
Excavators with a bucket capacity of 2-3 cu m	--	9
Drag lines with a bucket capacity of 10 cu m	1	--
Locomotives	--	16
Dump cars	--	140

(Continued)

Indexes	Nontransport System with Heavy Excavators	Transport System
Main coal-mining equipment		
Excavators with a bucket capacity of 3-4 cu m (with lengthened boom)	1	--
Excavators with a bucket capacity of 1.5 cu m	--	3
Locomotives (with MPS coal cars)	4	3
Number of workers employed	283	1,060
Productivity per worker (tons)	15-10	3.3-1.9
Weight of equipment and materials per 1,000 tons of daily extraction (tons)	810	1,460
Electric power consumption (kw-h/ton)	6.55	2.5
Cost of equipment per 1,000 tons of daily extraction (1,000 rubles)	4,600	5,850

Table 4

Indexes	Nontransport System	Transport System
Annual volume of overburden removal (1,000 cubic meters)	4,000	4,000
Overburden removal (cu m)	2.8-3.6	2.8-3.6
Maximum height of stripping bench (meters)	35	35
Annual coal production (1,000 tons)	1,200-950	1,200-950
Main equipment for stripping		
Excavators with a bucket capacity of 15 cu m	1	--
Excavators with a bucket capacity of 2-3 cu m	--	13
Drag lines with a bucket capacity of 10 cu m	1	--
Locomotives	--	25
Dump cars	--	150
Main coal-mining equipment		
Excavator with a bucket capacity of 1 cu m	3	--
Dump trucks with a 10-ton capacity	12	--

(Continued)

Indexes	Nontransport System	Transport System
Number of workers employed	295	1,870
Productivity per worker (tons)	11.6-9.2	1.85-1.45
Weight of equipment and materials per 1,000 tons of daily extraction (tons)	590	3,200
Electric power consumption (kw-h/ton)	4.00	2.5
Cost of equipment per 1,000 tons of daily extraction (1,000 rubles)	4,540	15,100

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